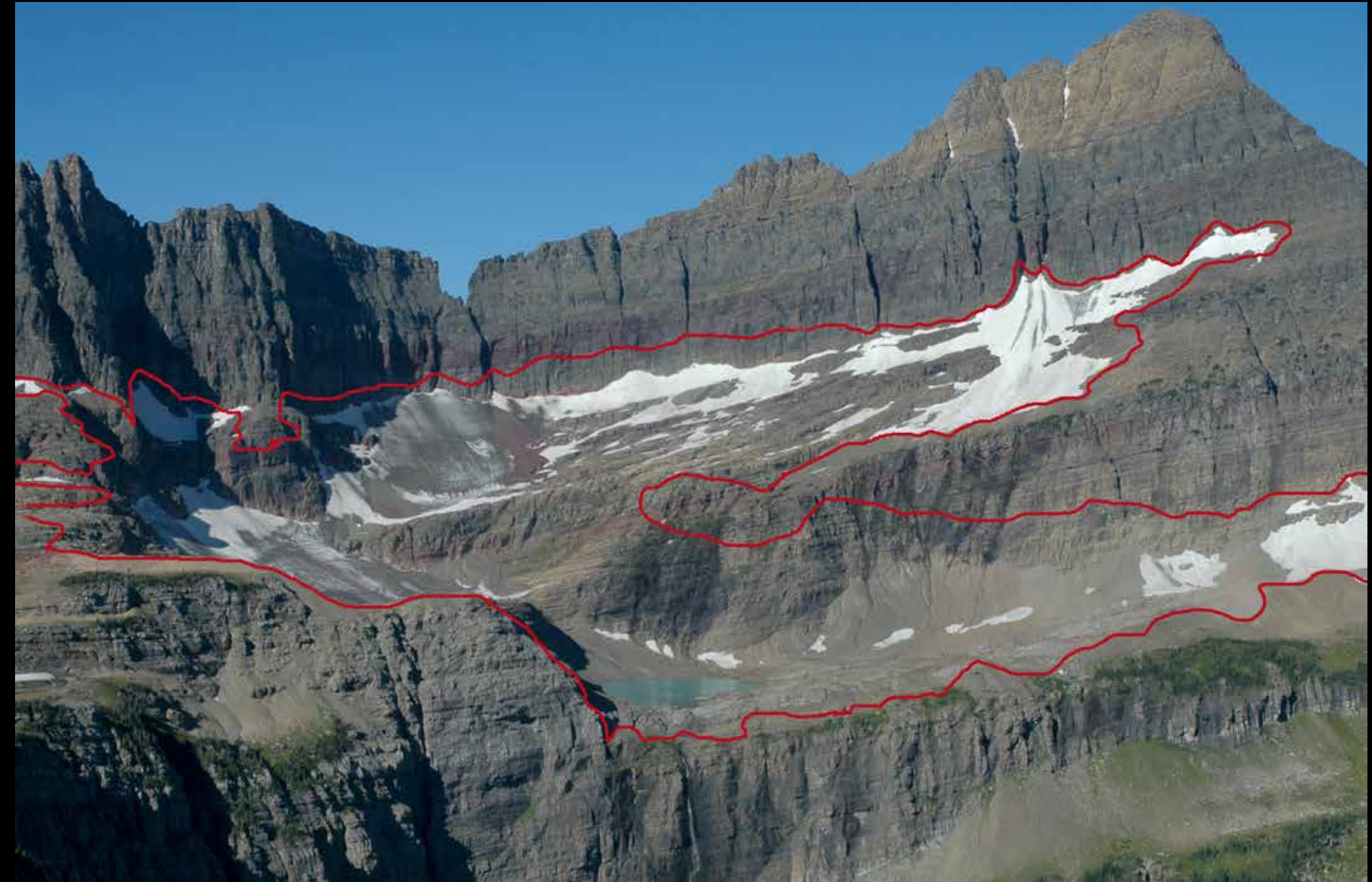


# Shepard Glacier



1913 - Photo by W.C. Alden, Glacier National Park.



2005 - Photo by B. Reardon, United States Geological Survey.

## Shepard Glacier, 1913 - 2005

What changes are obvious and not so obvious in the photo pairs above? The red line on the 2005 repeat photo of Shepard Glacier shows the 1913 glacier boundary. This pair illustrates one of the more dramatic cases of disappearing glaciers. In the 1913 photograph, thick ice is evident along the bottom lobe of the glacier and extensive crevasses (deep open cracks in

the ice) are present on the upper section indicating the glacier is flowing and has significant mass. By 2005, however, the contemporary photograph shows no ice on the bottom shelf, a small meltwater pond (center), and virtually no ice.

Shepard Glacier, at its current rate of retreat, is below 25 acres and is no longer considered a

viable glacier. What is a glacier? A glacier is defined as a body of snow and ice that moves. A commonly accepted guideline for glacier movement is that a glacier must be at least 25 acres in size. Below this size, the ice is generally stagnant and only moves if it is on a steep slope.

## Glacier National Park





## Thunderbird Glacier



1907 - Photo by M. Elrod, Glacier National Park.



2007 - Photo by Fagre/Peterson, United States Geological Survey.

### Thunderbird Glacier, 1907 - 2007

A century of glacial change can be seen from the Thunderbird pair. Acquiring the contemporary photograph involved some serious scrambling on cliffs and made USGS scientists admire Morton Elrod, the original photographer, who carried much heavier and bulkier gear over the same terrain.

Thunderbird Glacier is now made up of numerous patches of ice and, when closely examined, the 2007 photo reveals a number of cliff bands that were covered by ice in 1907. The corner of a tiny lake is just visible in the 2007 photo. Thunderbird Glacier will probably disappear within a few years now that it is reduced to a collection of ice patches.



Historic camera gear traveled on horseback.

### Glacier National Park





# Jackson Glacier



1911 - Photo by M. Elrod, University of Montana.



2009 - Photo by L. McKeon, United States Geological Survey.

## Jackson Glacier, 1911 - 2009

Jackson Glacier was once part of Blackfoot Glacier, one of the largest glaciers in the park. By 1939 the expanse of Blackfoot Glacier had receded and separated into two distinct basins, giving rise to the separate names of Jackson and Blackfoot glaciers.

Along with the glacial recession evident from this pair, can you

pick out another big change? Look at the vegetation establishment along Jackson Glacier's terminus (end point).

Although melting glaciers are the most visible indicators of climate change in the mountains, the entire mountain ecosystem is responding. Using both repeat photography and tree-ring studies, scientists have

documented that trees are growing faster, becoming taller and filling in the spaces in between trees. Young seedlings have established and are surviving in areas where deep snowpack and harsh weather conditions had previously excluded them.

How will this vegetation change impact alpine wildlife?

## Glacier National Park





# Grinnell Glacier



1911- Photo by Stanton, United States Geological Survey.



2008 - Photo by L. McKeon, United States Geological Survey.

## Grinnell Glacier, 1911 - 2008

The 1911 photo shows Grinnell Glacier poised at the top of the mountain range with waterfalls in the foreground and joined with what is now called Salamander Glacier in the background. George Bird Grinnell described this wall of ice as being 1,000 feet high in 1887. As of 2008, the wall of ice was gone and Grinnell Glacier is no longer visible in the contemporary photograph.

The Salamander Glacier, now separate, lies along the wall below the ridgeline. This glacier is thinning in the middle so rapidly that it will likely be in two pieces within a few years. Perched on the upper left wall is the small, rounded Gem Glacier. Although its area has remained stable, the glacier is losing volume.

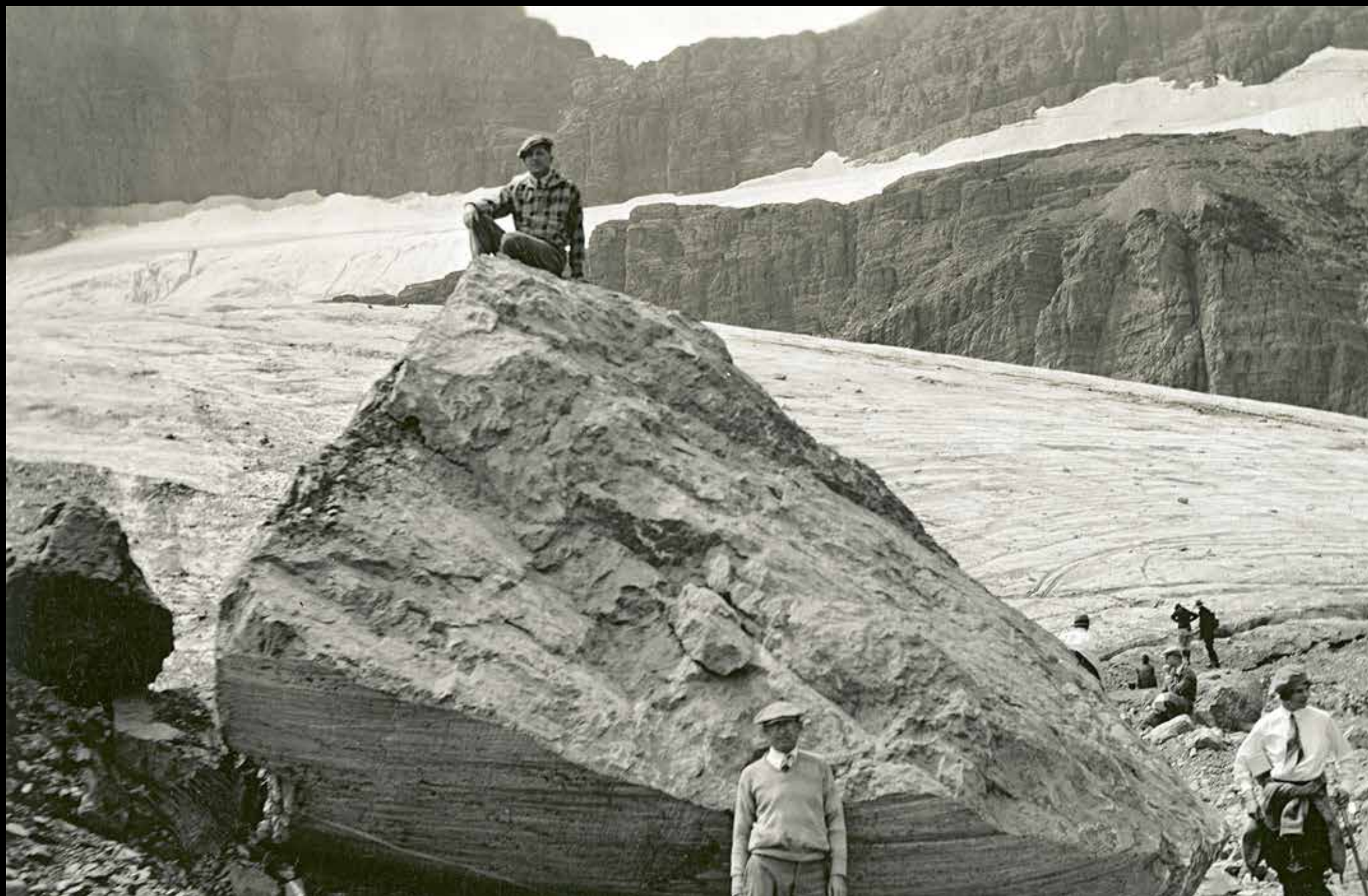
Do all glaciers melt at the same rate? No, melting rates vary for glaciers based on climate and other influences such as aspect, elevation, input of wind distributed snow, and the presence of a meltwater lake along the glacier's edge. Even so, overall trends show glaciers in the park are receding.

## Glacier National Park





# Grinnell Glacier



1926 - Photo by M. Elrod, University of Montana



2008 - Photo by L. McKeon, United States Geological Survey.

## Grinnell Glacier, 1926 - 2008

What makes a good photo to re-photograph? Historic images with easily recognizable landscape features, like the photo above, make relocating the photo easier.

The large boulder in front of Grinnell Glacier was used by Morton Elrod and other scientists as a baseline to measure the retreat of the

glacier. The boulder is now referred to as “Elrod’s Rock” and the glacier’s terminus (the end of the glacier) has retreated a half mile from this point.

Did you also notice the number of people in the historic photo? Grinnell Glacier was and still is one of the most photographed glaciers in the park. In the early 1900s, park visitors were able

to hike or horseback ride eight miles up the Many Glacier Valley to see this glacier. Today, this is a strenuous, but still popular hike once the snow has melted from the trail in late summer.

## Glacier National Park





## Boulder Glacier



1932 - Photo by T.J. Hileman, Glacier National Park.



1988 - Photo by J. DeSanto, University of Montana.

### Boulder Glacier, 1932 - 1988

This is one of the earliest photographs repeated from the park that shows the disappearance of glacial ice. It helped to start the current Repeat Photography Project.

The 1932 photograph shows a guide, wearing chaps, and three clients next to the ice cave. This was one of the popular multi-day routes during the heyday

of horseback trips through the park and underscores the charisma that glaciers had for early park visitors.

The 1988 photo not only shows a completely ice-free view 56 years later, but shows how vegetation has moved into the area vacated by the glacier. Boulder is now too small to be considered a viable glacier.

What do these image pairs imply about climate change? The climate is warming. Glaciers respond to temperature and precipitation, reflecting long-term trends. These small alpine glaciers are like a visual checking account of the status of the frozen part of the ecosystem.

### Glacier National Park





## Sperry Glacier



Circa 1930 - Photo by M. Elrod, University of Montana.



2008 - Photo by L. McKeon, United States Geological Survey.

### Sperry Glacier, Circa 1930 - 2008

Repeating Elrod's photograph from the same photo point was impossible since the historical photograph was shot from the elevated perspective of the glacier's surface. The terminus of the glacier has retreated beyond the field of view, but these images give a sense of the glacier's extent and mass early in the twentieth century.

Sperry Glacier is a benchmark glacier for USGS scientists. They use its measurements of annual change as a baseline to compare with other glaciers and to predict future changes.

Glaciers store about 69% of the world's freshwater and cover almost 10% of the world's land mass. They act as a "bank" of water (stored as ice) whose

continual melt helps regulate stream temperatures and maintain stream flow during late summer and drought periods when other sources are depleted. Without glacial meltwater, summer water temperatures will increase and may cause the local extinction of temperature sensitive species, such as aquatic insects and native trout.

### Glacier National Park

